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Moher

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[54] **JOINT DETECTOR FOR MULTIPLE CODED DIGITAL SIGNALS**

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[52] **U.S. Cl.** **714/780**; 714/746; 714/786; 714/795; 375/262; 375/341

[58] **Field of Search** 371/30, 43.1, 43.6, 371/43.7, 43.4; 375/262, 341; 714/746, 786, 794, 795, 792, 780

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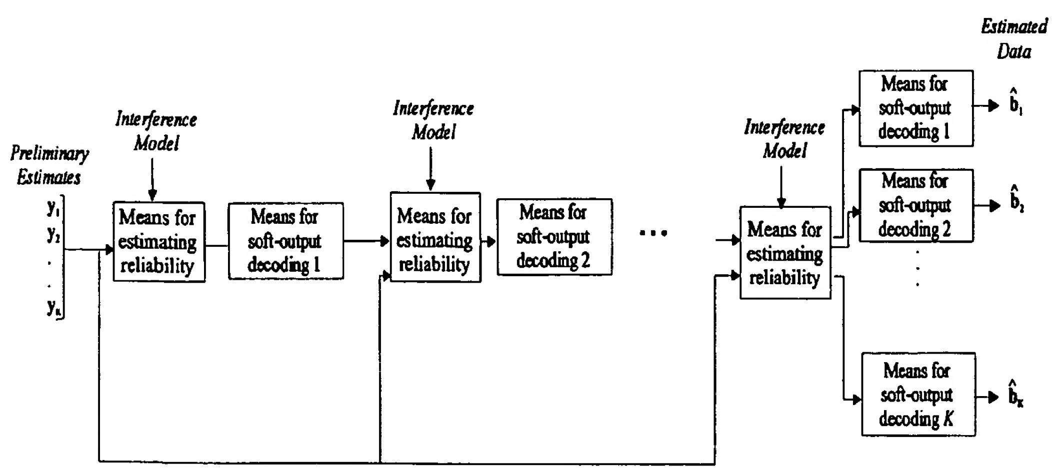
[57] **ABSTRACT**

A method for the joint detection of multiple coded digital signals that share the same transmission medium in a manner that causes mutual interference. The method is comprised of two steps that are applied to preliminary estimates of each digital signal, one or more times. The first step is to obtain reliability estimates for each data element of each digital signal by combining the preliminary estimates, a statistical model for the interference, and any a priori information regarding the data elements. The second step is to revise these reliability estimates for each digital signal based on the forward error correction code used for that digital signal. When the steps are repeated, the revised reliability estimates from the second step are used as a priori information for the first step.

19 Claims, 61 Drawing Sheets



Theorem 4.1. Capacity of the K-symmetric channel with diversity. The theoretical capacity of the K-symmetric channel is given by

$$C(\gamma) = \frac{K-1}{2}\log_2[1 + D_g(1-\rho)\gamma] + \frac{1}{2}\log_2[1 + D_g(1 + (K-1)\rho)\gamma]. \quad (179)$$

As $\rho \to 0$, then

$$C(\gamma) \overset{\rho\to 0}{\longrightarrow} \frac{K}{2}\log_2(1+\gamma) \quad (180)$$

that is, K times the capacity of the single user channel. As $\rho \to 1$, the theoretical capacity approaches

$$C(\gamma) \overset{\rho\to 1}{\longrightarrow} \frac{1}{2}\log_2(1 + K^2\gamma). \quad (181)$$

The factor K^2 is due to combination of the K users' power plus a diversity gain of K.

Shown in FIG. 65 is the theoretical capacity of the K-symmetric channel with diversity for five users. As one observes, the capacity decreases as the correlation parameter (ρ) increases at least for $\bar{E}_b/N_0$ ratios above 0 dB. The capacity is clearly much greater than in the non-diversity case.

The decrease in capacity from ρ=0.90 to ρ=1 is significantly larger than the decrease from ρ=0 to ρ=0.90. Combine this observation with the observations that i) the threshold SNR increases as the ρ value increases and ii) capacity increases with SNR, supports the conjecture that the threshold is dependent upon capacity considerations.

The diversity performance curves appear as shifted versions of the corresponding non-diversity results. The same is true of the theoretical capacity of the K-symmetric diversity channel relative to the non-diversity channel. However, when there is even a marginal improvement from the first iteration to the second, the algorithm can bootstrap itself and achieve single user performance.

Of course, numerous other embodiments other than those described heretofore may be envisaged, without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of detecting a plurality of digital signals that are forward error correction encoded and mutually interfere comprising the steps of:

(a) using a detector, detecting the plurality of digital signals and providing detector estimates of a first digital signal and second other digital signal from the plurality of digital signals;

b) (i) using a processor receiving the detector estimates and calculating a reliability estimate for each data element of first digital signal from the plurality of digital signals, the reliability estimate calculated from detector estimates of those data elements, a model of the interference, and a priori information determined in previous iterations, if any, concerning those data elements;

(ii) using a processor, calculating a reliability estimate for each data element of a second other digital signal from the plurality of digital signals, the reliability estimate calculated from detector estimates of those data elements, a model of the interference, and a priori information determined in previous iterations, if any, concerning those data elements;

c) using the processor, calculating a revised reliability estimate for each data element in dependence upon the reliability estimates from the step (b) and the properties of the forward error correction code for the corresponding digital signal; and

d) repeating the previous two steps, one or more times, using the revised reliability estimates provided by step (c) as a priori information for the step (b).

2. A method as defined claim 1 wherein during the first step (a), the processor uses only a subset of data when calculating the reliability estimates.

3. A method as defined in claim 1 wherein during the second step (b), the processor uses only a subset of the data when calculating the revised reliability estimates.

4. The method as defined in claim 1 wherein the first and second steps (a) and (b) provide reliability estimates for a subset of the K digital signals.

5. A method as defined in claim 1, wherein step (b) comprises the step of using a soft-output decoder, performing soft-output decoding.

6. A method as defined in claim 5 where the step of soft-output decoding is implemented for a plurality of digital signals using a single soft-output decoder.

7. A method as defined in claim 5 wherein the step of soft-output decoding is applied to a subset of K digital signals.

8. A method as defined in claim 5 where the step of soft-output decoding is implemented in parallel for each of a plurality of digital signals.

9. A method as defined in claim 1 comprising the step of:

receiving a plurality of substantially similar digital signals from a plurality of receivers;

wherein the detector detects data elements within at least two of the received digital signals and provides the preliminary estimates of those signals; and,

wherein the steps (a)(i) and (ii) are performed in dependence upon the plurality of substantially similar digital signals from a plurality of receivers.

10. The method as defined in claim 1 including the step of outputting information content of one or more of the digital signals.

11. A method of detecting a plurality of digital signals that are forward error correction encoded and mutually interfere comprising the steps of:

a) providing preliminary estimates of the plurality of detected digital signals to a processor;

b) using the processor, calculating a reliability estimate for each data element of each digital signal from preliminary estimates of those data elements, a model of the interference, and a priori information, if any, concerning those data elements;

c) using the processor, calculating a revised reliability estimate for each data element in dependence upon the reliability estimates from the step (b) and the properties of the forward error correction code for the corresponding digital signal; and,

d) providing corrected estimates of each of the plurality of digital signals, the corrected estimates corrected from the preliminary estimates based on the calculated and revised reliability estimates.

12. A method of detecting as defined in claim 11 comprising the step of repeating steps (b) and (c) one or more times, using the revised reliability estimates provided by the step (c) as a priori information for step (b).

13. A method as defined in claim 12, wherein step (c) comprises the step of soft-output decoding.

14. The method as defined in claim 12 including the step of using a detector, detecting the plurality of digital signals and providing detector estimates of a first digital signal and second other digital signal from the plurality of digital signals.

15. A system for detecting a plurality of digital signals that are forward error correction encoded and mutually interfere, given preliminary estimates of those signals, comprising:

a processor having an input and an output, the processor comprising:

means for calculating a reliability estimate for each data element of at least two different digital signal from the plurality of digital signals in dependence upon the preliminary estimates of those data elements, a statistical model of the interference, and a priori information, if any, concerning those data elements; and,

means for calculating a revised reliability estimate for each data element based on the reliability estimates calculated and the properties of the forward error correction code for the corresponding digital signal; and,

means for providing corrected estimates of the data elements of each of the first and second digital signals, the corrected estimates corrected based on the calculated and revised reliability estimates.

16. A system of detecting a plurality of digital signals as defined in claim 15, including a suitably programmed processing means for performing said calculations.

17. A system as defined in claim 16 including feed back means for providing feedback from the output to the input.

18. A system as defined in claim 15 including output means for outputting information content of one or more of the digital signals.

19. A system as defined in claim 15 comprising:

a plurality of transmitters for transmitting data signals via a common communications channel;

a model of mutual interference between signals transmitted from the transmitters from the plurality of transmitters; and,

a plurality of detectors for detecting mutually interfering digital data signals and for providing the detector estimates of those signals to the processor.

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